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A CORRELATION OF THE PRE-CAMBRIAN FORMATIONS OF NORTHERN ONTARIO AND QUEBEC[1]

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In a paper recently published in the *Journal of Geology*[2] the writer correlated the pre-Cambrian formations of northern Quebec as well as facts obtained during the last ten years would permit. The formations most satisfactorily correlated were a number of scattered patches of sediments which had been given the local names Pontiac, Mattagami, Broadback, and Brock series. In composition, succession, structure, and external relations these scattered patches of sediments were deemed sufficiently alike to warrant substituting the general name Mattagami series for the local names. The position of the Mattagami series in the geologic column is shown in the following succession:

Mistassini limestone
Unconformity
Diabase dikes
Intrusive contact
Cobalt series
Great unconformity
Granite
Intrusive contact
Lamprophyre dikes
Intrusive contact
Mattagami series
Unconformity
Gabbro and anorthosite
Intrusive contact
Granite-gneiss (around Lake St. John)
Intrusive contact
Nemenjish series (Grenville series ?)
Abitibi volcanics (basalts, andesites, rhyolites)

During 1918 the writer had an opportunity to examine for the first time the Timiskaming series in the Kirkland Lake district of northern Ontario, and was so impressed by its similarity to the Mattagami series that further opportunity was taken in 1919 to investigate its relation to that series. The results indicate beyond any reasonable doubt that the Mattagami series and the Timiskaming series of Kirkland Lake may be correlated and grouped together under a single name.

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[1] Published by permission of the Geological Survey of Canada.

[2] *Journal of Geology*, Vol. XXVII, Nos. 2, 3, 4, 5, 1919.

LOCATION

The area of Mattagami series nearest to the Kirkland Lake district is the Pontiac area lying south of the National Transcontinental Railway between the Ontario-Quebec boundary and the Bell River. Between the two districts lies the Larder Lake district, 12 miles in width. The three districts together form a narrow strip of territory about 130 miles from east to west, and 25 miles from north to south (Fig. 1). The shaded area in Figure 1 shows

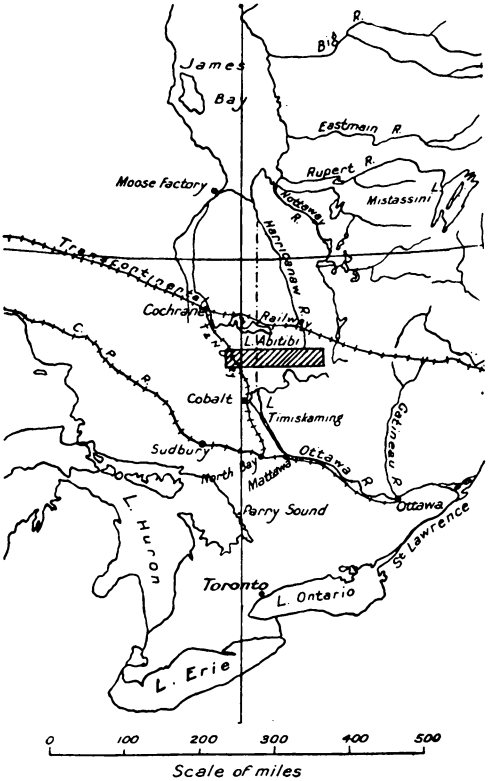

FIG. 1.—Index map showing location (hatched) of area dealt with in this paper

the general location of this strip within which lie the sediments whose correlation is dealt with in this paper. The Timiskaming Northern Ontario Railway passes through its western end, affording access to the important mining center of Kirkland Lake through Swastika station, and to Larder Lake through Dane station. The only access to the Quebec portion of the area is by canoe from Lake Timiskaming, Larder Lake, or the National Transcontinental Railway.

PREVIOUS WORK AND CONCLUSIONS

Reconnaissances along easily accessible water routes were made as early as 1900 by W. J. Wilson,[1] W. G. Miller,[2] L. L. Bolton,[3] Walter McOuat,[4] W. A. Parks,[5] J. Obalski,[6] and J. F. E. Johnston,[7] but the first detailed work appears to have been that of Brock[8] and Bowen,[9] in 1908, at Larder Lake. In the four years following the whole of the area shown in Figure 1 was mapped in more or less detail by A. G. Burrows, and P. E. Hopkins,[10] E. L. Bruce,[11] M. E. Wilson,[12] R. Harvie,[13] and J. A. Bancroft.[14]

These writers have reached very different conclusions regarding the age and external relations of the sediments in this strip of territory. Burrows and Hopkins (1912) consider the sediments of Teck, Lebel, and Gauthier townships to be a single series of interbedded conglomerates and greywackes folded into a tight syncline with vertical or very steep limbs. Miller correlates this series with a similar closely folded conglomerate near Cobalt, previously called Timiskaming series. They recognize that it is much older than the Cobalt series, since the latter is found in Grenfell Township, to the west of Teck, lying flat within a quarter of a mile of the folded Timiskaming. The Cobalt series is regarded as probably Upper Huronian or Animikean in age, and the Timiskaming as Lower Huronian.[1]

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[1] W. J. Wilson, *Geol. Surv. Can., Sum. Rept.*, 1901, pp. 117A–130A; *Geol. Surv. Can., Mem. No. 4*, 1910.

[2] W. G. Miller, *Ont. Bur. of Mines, Rept. No. 14*, pp. 261–68, 1905; *Rept. No. 11*, pp. 214–30, 1902.

[3] L. L. Bolton, *Ont. Bur. of Mines, Rept. No. 12*, pp. 173–90, 1903.

[4] W. McOuat, "Rept. of Prog.," *Geol. Surv. Can.*, 1872, 1873, pp. 112–35.

[5] W. A. Parks, *Geol. Surv. Can., Sum. Rept.*, 1904, pp. 198–225.

[6] J. Obalski, *Mining Operations in the Province of Quebec*, 1906, pp. 5–27; 1907, pp. 42–56.

[7] J. F. E. Johnston, *Geol. Surv. Can., Sum. Rept.*, 1901, pp. 130A–143A.

[8] R. W. Brock, *Ont. Bur. of Mines Rept. for 1907.*

[9] N. L. Bowen, *Ont. Bur. of Mines Rept. for 1908.*

[10] Burrows and Hopkins, *Ont. Bur. of Mines Rept. for 1913.*

[11] E. L. Bruce, *Ont. Bur. of Mines, Rept. for 1912.*

[12] M. E. Wilson, *Geol. Surv. Can., Mem. Nos. 17, 39.*

[13] R. Harvie, *Report of Mining Operations in the Province of Quebec during 1910.*

[14] J. A. Bancroft, *Report of Mining Operations in the Province of Quebec during 1912.*

The sediments continue without interruption (Fig. 3) from Gauthier Township eastward into McVittie and McGarry townships (Larder Lake district), where they are described by Brock and Bowen (1907) and later by M. E. Wilson (1908–9) as consisting of slates, carbonate rocks, and greywackes interbedded with basic altered lavas and therefore as of Keewatin age. Some steeply dipping conglomerates found to the north and south of the slates and other rocks are mapped as isolated patches of Cobalt conglomerate deformed by local disturbance.

Some four miles to the east of Larder Lake there outcrops the sedimentary series named the Pontiac schists by M. E. Wilson. These are separated from the Larder Lake sediments by a band of flat-lying sediments belonging to the Cobalt series (Fig. 3). The Pontiac series has been described by M. E. Wilson and J. A. Bancroft as a series of interbedded conglomerate and greywacke, folded into a vertical position, overlying the Keewatin unconformably, and underlying the Cobalt series with great unconformity. The similarity of the descriptions of the Pontiac conglomerates and greywackes and the corresponding members of the Timiskaming series of Kirkland Lake is pronounced.

The geological descriptions which have been briefly summarized appeared to the writer to indicate either that some error had been made in the study of one of the areas, or that there was more there than any of the geologists had recognized. Under the latter hypothesis it was conceived that there might be two ancient sedimentary series in the district, one of which was the better developed in each area, and that a different one had been recognized by each set of investigators. To determine if possible which of these hypotheses was the correct one, the writer in 1919 visited Larder Lake and made a study of the part of the area in doubt.

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[1] *Ont. Bur. Mines, Repl. No. 22*, pp. 123–27, 1913.

INVESTIGATIONS AT LARDER LAKE (FIG. 2)

A conglomerate outcropping prominently on the Larder townsite was the first thing to attract the writer's attention. This conglomerate is mapped by Brock and Wilson as belonging to the Cobalt series, but evidently with reservation on the latter's part, as he describes it thus:[1]

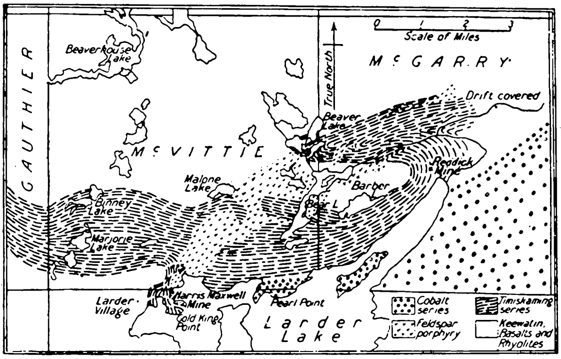

FIG. 2.—Larder Lake area

> There is an area of mashed conglomerate on the north shore of Larder Lake, at Larder City, which has been intruded in a most complex manner by a hornblende lamprophyre, vogesite. *The pebbles of this conglomerate differ from the normal type* in that they consist entirely of quartz porphyry, rhyolite, and iron formation. . . . . The occurrence of the lamprophyre cutting the sheared conglomerate suggests that this conglomerate may be the equivalent of Dr. Miller's Timiskaming series.

Again, on page 37:

> In the neighbourhood of Larder Lake there are numerous areas of conglomerate which have been greatly mashed in a direction parallel to the strike of the underlying Keewatin. These conglomerates might have any one of the three following relationships to the other rocks of the region: (1) They might be Keewatin conglomerates deposited between the volcanic flows of

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[1] *Geol. Surv. Can., Mem. No. 17*, p. 38.

that series in a manner somewhat similar to the interflow conglomerates which occur in the lower portion of the Keewanawan series. (2) They might belong to an older Huronian series, that is, a series younger than the Keewatin but older than the *undisturbed* Huronian. (3) They might be portions of the ordinary flat-lying series which have suffered local disturbance.

Wilson concluded to map all the mashed conglomerates under the third hypothesis, as locally sheared Cobalt series. The only evidence in support is given on page 38:

> It was also observed that in some outcrops where the mashed conglomerate has a considerable vertical thickness, the schistosity appears to diminish from the base upward, as if the contact of the flat-lying Huronian and the Keewatin might have served as a plane of deformation. This phenomenon can be seen in a conglomerate hill situated on the northern boundary of claim H.J.B. 21, in McGarry Township.

A plane of contact very commonly does function as a gliding plane during folding, so that the rocks close to it are apt to be more schistose than those farther away without regard to the age of the series; but the foregoing inference would be valid only if the schistose strata passed gradually into flat-lying beds, which they do not. The writer found that this conglomerate forms part of the conglomerate of the Timiskaming series.

To the east of Larder Village, across a small bay, Gold King Point projects into the lake. The greater part of this point is mapped as Keewatin on the early maps, with a small patch of conglomerate near the southeastern extremity; but the point was stripped clean of vegetation by fire three years ago, and the present exposures show clearly that the conglomerate is not a patch but a continuous band about 30 feet in width, dipping vertically and with its strike swinging from north 60 degrees west at the southeastern tip of the point to north near the Harris-Maxwell mine (Fig. 2). The conglomerate, like that on the Larder townsite, contains pebbles of basalt, rhyolite, jasper and iron formation. It is intruded by a feldspar porphyry like that of Kirkland Lake, and by dikes of lamprophyre. On the east side, where not intruded by porphyry or lamprophyre, it is in contact with massive basalt, exhibiting good pillow structure, and contains basalt pebbles. The rocks on the west of the conglomerate are not Keewatin, but well-bedded greywackes, showing fine lines of cross-bedding in places; the dip and strike of the greywacke parallel those of the conglomerate.

It is evident therefore that these rocks, with those on the Larder townsite, are parts of a small tightly folded syncline, the axis of which has a north-south strike between the village and the Harris-Maxwell mine. It was also apparent that they lie unconformably on the greenstones, as the rhyolite, basalt, jasper, and iron formation are all members of the underlying volcanic complex.

A mile and a half to the east, on Pearl Point (Fig. 2) normal conglomerate and slate of the Cobalt series outcrops. The conglomerate is massive, at least 100 feet thick, and crowded with pebbles of all sizes. From 75 to 90 per cent of the pebbles are granite, the remainder other rocks. The conglomerate dips 15 degrees to 20 degrees, and is overlain by the normal argillite of the series, fine grained, black, and well bedded, containing an occasional pebble. The composition, succession, and structure of these rocks is so utterly different from those at Larder Village only 1½ miles away that it is difficult to conceive them to be of the same formation.

Accordingly the writer returned to trace northward the band of conglomerate that passes across the Larder townsite. It runs somewhat east of north for about half a mile, then swings to the east across a drift-filled valley, on the other side of which it was easily picked up again and traced a short distance farther north, till, turning west, it passes beneath a large sand plain. Two miles to the west it has been mapped by both Wilson and Burrows on the shore of the Blanche River.

About half a mile to the north of the Harris-Maxwell mine (Fig. 2) an interesting set of relations occurs. The basal band of conglomerate, composed as before mainly of pebbles of rhyolite, jasper, and iron formation, here striking south 40 degrees east and with vertical dips, is overlain conformably on the east by interbanded greywacke and conglomerate, the conglomerates gradually becoming finer grained, passing into coarse grits and then into fine grits. Above the grits and greywackes occur some hundreds of feet of soft, slaty argillites, whose strike and dip parallel those of the conglomerate. All these rocks are greatly broken up by intrusive dikes and masses of porphyry.

Lying on the upturned edges of these rocks is a second conglomerate, a massive rock composed almost entirely of greenstone fragments with about 10 per cent of granite pebbles, lying flat, and showing vague cross-bedding in places. This conglomerate occurs in irregular patches and knobs, evidently erosion remnants, lying indifferently on the older slates, greywackes, grits, and conglomerates. The writer concluded from the composition, which is characteristic of the base of the Cobalt conglomerate, and from the lack of deformation that it is an erosion remnant of the Cobalt conglomerate found to the east in larger masses; the areal relations to the underlying sedimentary series show that there is a large unconformity between the two.

The earlier geologic maps show a number of patches of conglomerate, mapped as Cobalt series, lying to the north of the areas of Larder slate, in many cases some distance to the north and within areas of Keewatin. These conglomerates proved on examination to consist invariably of beds dipping to the south at angles varying from 60 to 90, and frequently badly sheared. Their composition is like that of the conglomerate of the Larder townsite, in that the pebbles are largely of rhyolite, banded chert, jasper, and iron formation, with some basalt, although commonly the proportion of rhyolite is larger and that of iron formation smaller than on the townsite. The rocks to the north of the conglomerate band are invariably basalts except around Malone Lake, where rhyolite occurs; and almost invariably they exhibit pillow structures and other characteristics of lavas. The conglomerates were found to form, not isolated patches, but a strong band, continuous throughout the district, except where broken by intrusive masses of porphyry, and where, for a short distance to the east of Barber Lake, it has been obliterated by thinning and intense shearing.

The rocks to the south of the conglomerate band were then carefully examined, as some of them had been previously mapped as Keewatin. A great deal of excuse for the earlier mapping was found, in that in many cases the rocks are massive, dark green, chloritic rocks, indistinguishable in the average hand specimen from the usual altered basalt. This is particularly the case in the area about 2 miles due north of Larder Village. But careful detailed examination showed that nowhere are there any ellipsoidal structures or amygdaloidal or other textures characteristic of lavas, although the massive character of the rocks indicates that these textures would have been preserved had they ever existed. On the contrary, bedding was observed at many points where exposures were clean and free from moss. Stratification is rarely prominent, but always distinct, being marked by slight changes in color, composition, and grain. It was clear therefore that these rocks are not lavas, but greywackes, presumably composed of the débris of eroded basalt flows. This conclusion was strengthened by finding in many places on clean weathered surfaces occasional angular or subangular grains of basalt.

Since these rocks are thus proved to be sediments, not lavas, the earlier conclusions as to the interbedding of the Larder Lake sediments with lavas become invalid, together with the conclusions drawn therefrom as to the Keewatin age of the sediments. As there is no observed unconformity between the different bands of sediments, it is concluded that they form a single series, infolded with the older volcanics into a tight syncline. This series of sediments rests unconformably on the Keewatin, since the basal conglomerate is composed mainly of Keewatin material, and is overlain with structural unconformity by the Cobalt series. It is intruded by feldspar porphyries and by lamprophyre dikes. Because of its stratigraphic position, lithological similarity, and geographic continuity (Fig. 3) the series is clearly a continuation of the Kirkland Lake Timiskaming.

Figure 3 shows the Timiskaming to be a strong band 1½ to 2 miles in width, with a general east-west trend. Less than 3 miles due east of where the band is concealed by the Cobalt series on the east side of Larder Lake, the Pontiac series outcrops, and continues as a strong band for another hundred miles eastward. J. A. Bancroft has shown that the external relations of the Pontiac series are identical with those of the Timiskaming series; both overlie the Keewatin with unconformity, are intruded by granites, and are overlain by the Cobalt series with great unconformity.

Both are deformed along east-west axes and the basal conglomerates of both are so similar that the writer has been unable to distinguish them. In view of these facts there can be no reasonable doubt as to the correlation of the two series. Since the Pontiac series has already been correlated with other ancient sediments of northern Quebec under the general name of Mattagami series, a general correlation of northern Ontario and Quebec is thus established. The name Timiskaming, which has priority, will henceforth be used in this report in referring to these sediments both in Ontario and Quebec, replacing the name Mattagami series.

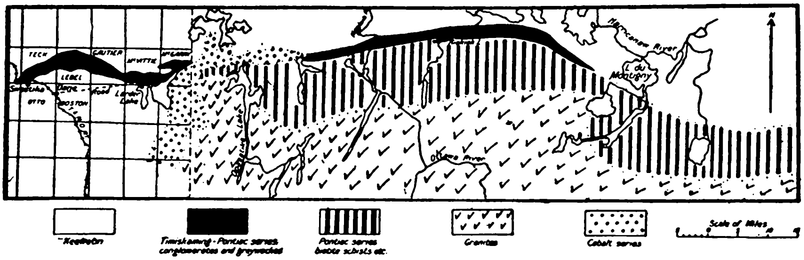
Ottawa River
Keewatin
Timiskaming-Pontiac series conglomerates and greywackes
Pontiac series biotite schists etc.
Granites
Cobalt series
Scale of Miles

FIG. 3.—Sketch map showing the lineal distribution of the Timiskaming-Pontiac series in Ontario and Quebec.

ECONOMIC VALUE OF THE CORRELATION

The correlation thus established possesses a certain economic value which may now be briefly discussed. The writer has recently shown[1] that in the Matachewan district of northern Ontario valuable gold deposits have been formed through the action of juvenile solutions originating from a body of cooling syenite porphyry. Similar porphyries are found in many places through northern Ontario, and very commonly in association with gold deposits. While the genetic connection of the gold deposits with the porphyry has never been definitely proved, so far as the writer is aware, in any district but that of Matachewan, still the frequency with which the association occurs is extremely suggestive. The porphyries intrude the Keewatin volcanics in dikes, batholiths, and rarely sills; when they intrude the Timiskaming series the bedded structure of the latter causes them commonly to assume the form of sills. Gold deposits have not as yet been found around the batholiths, presumably because the upper contacts, where juvenile waters might have deposited ores, have been eroded away, while the lower surfaces are not exposed. The porphyry dikes frequently have gold deposits associated with them, but it is commonly found that such deposits are small, presumably because the dikes are not large enough to have afforded any great amount of juvenile water. The most favorable form for the porphyry to assume would seem in theory to be the sill, which combines a large volume with a relatively small thickness, together with the exposure of both edges, in tilted rocks. The facts correspond with the theory, inasmuch as within the boundaries of the Timiskaming series, where the porphyries commonly form sills, gold discoveries have been very numerous, and many of the discoveries have been developed into producing mines.

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[1] *Economic Geology*, Vol. XIV (1919), pp. 281–301.

The syenite porphyry is found in large amount throughout the Kirkland and Larder Lake districts, and was found by the writer in Quebec, to the east of the Larder Lake area, and also on Lake de Montigny, near the east end of the Pontiac area. It would seem likely therefore that it may be found intruding the Timiskaming series throughout its whole length of 130 miles although perhaps not in such volume as in the Kirkland and Larder areas. Thus the correlation between the Timiskaming and Pontiac series increases the Timiskaming area, already recognized as very favorable for prospecting, to four times its former known size.

EXTERNAL RELATIONS OF THE TIMISKAMING SERIES

Facts already briefly stated in the foregoing pages indicate that the Timiskaming series overlies the Keewatin unconformably, is intruded by granitic rocks, and is overlain with great unconformity by the Cobalt series. In view, however, of the disagreement that has existed in the past between those studying the districts under consideration, it seems advisable to enlarge somewhat on the previous statements.

Relations to the Keewatin.—The basal conglomerate of the Timiskaming series contains pebbles of all the volcanic series, as well as a few pebbles of granite and syenite. The volcanics observed in the basal conglomerate include basalt, andesite, rhyolite, iron formation, red jasper, and various cherts and tuffs, many of them possessing well-defined bedding. Schistosity in the pebbles was observed in one place only, near Kenogami station on the Timiskaming and Northern Ontario Railway, where a few pebbles of a peculiar volcanic breccia are sheared. (This statement naturally applies only to such bodies of conglomerate as have not been sheared as a whole. Where this has taken place the pebbles are to be found in all stages of mashing.) The pebbles in the basal parts of the conglomerate are very well rounded, thus evidencing considerable wear before final deposition.

Wilson has argued that the presence of pebbles of the volcanics does not constitute proof of unconformity, and while he does not exclude the possibility of unconformity he regards it as possible that the conglomerates do not represent any long erosion interval. It is true that the presence of the lava pebbles is not full proof of unconformity, and the writer will go farther and admit that even the granite pebbles do not necessarily indicate unconformity, since he has found a few granite pebbles in coarse tuffs interstratified with Keewatin basalts. The conclusive evidence of unconformity is found in the presence of pebbles of iron formation, bedded chert, etc. These are water-laid sediments, as is clearly shown by their thin uniform bedding, their frequent association with thin-bedded tuffaceous clastics, and their association in other places with pillow lavas, which are now commonly recognized as subaqueous extrusions. The presence and association of these pebbles in the Timiskaming conglomerate indicates conclusively that before the conglomerate could have been laid down there must have been uplift, some folding, and erosion of the underlying rocks. Unconformity is thus proved.

Relations to the granites.—The relation of the Timiskaming series to the ordinary granite of northern Ontario that contains a great deal of free quartz is not yet known, as such granite is not found in contact with the Timiskaming series at any known point. But granites of this type intrude the Timiskaming series in northern Quebec. At the contacts the sediments are more or less metamorphosed and recrystallized by the heat of the intrusive, and converted into hornblende and biotite gneisses, occasionally with development of some garnet. Dikes of granite and pegmatite pierce the sediments, and some blocks of the latter are found included in the granites often at considerable distances from the contacts. The included blocks are in all phases of digestion from sharp-angled fragments through phases in which the edges and corners have been partially or completely dissolved to phases in which the only remaining indication of a foreign mass is a vaguely outlined patch of material more micaceous than the surrounding granite. The contact of the granites and Timiskaming is different in degree, though not in kind, from a granite-Keewatin contact, in that it is a fairly sharp line, instead of being a wide zone of blocks of the older rock separated by dikes and masses of intrusive. This is undoubtedly due to the influence of the bedding of the Timiskaming series in controlling the intrusion.

The principal granitic rocks known to intrude the Timiskaming in Ontario are two: a grayish syenite in Lebel Township, and various bodies of syenite porphyry. The syenite body in Lebel Township is presumably, from its shape, a batholith; the porphyries may form fairly large batholithic masses, as in the case of the large mass north of Larder Lake, but more commonly they form smaller bodies the intrusion of which has been largely controlled by the bedding of the Timiskaming. They tend therefore to be sill-like in shape, although they may be observed to cut the bedding in numerous places. The chemical and mineralogical composition of the syenite batholith and the intrusive sills is so similar that there can be little doubt that they are but different forms of the same intrusive magma. The writer has not observed the contact of the Timiskaming series and the batholith in Lebel Township, but the mapping by the Bureau of Mines indicates that it is of much the same nature as the granite contacts in northern Quebec already described. The evidence of intrusion of the sills is more difficult to obtain, since the sills had practically no recrystallizing influence on the sediments, and rarely have a chilled edge, include blocks of sediment, or send off dikes into the sediments. The best evidence of intrusion is the areal evidence, obtained by mapping. Thus in McGarry Township porphyry masses are seen (Fig. 2) to cut across the bedding of the Timiskaming near its base, into the underlying Keewatin. The same thing on a smaller scale may be observed to the north of the Harris-Maxwell mine, where masses of porphyry cut across the bedding of the sediments, from the conglomerates into the overlying greywackes and slates.

Relations to the Cobalt series.—The Cobalt series overlies the Timiskaming with very great unconformity. The relations of the two series are seen in two places. In Grenville Township, near Kenogami station, the flat-lying Cobalt series outcrops a quarter of a mile northeast of the Timiskaming, which dips 60 to 70 degrees. The Cobalt series outcrops again near the Timiskaming series at Larder Lake. As mentioned previously, a small outcrop of the Cobalt basal conglomerate north of the Harris-Maxwell mine was observed to lie on a peneplaned surface beveling the Timiskaming series and the porphyries and lamprophyres which intrude it. The Cobalt conglomerate here lies in turn on Timiskaming conglomerate, greywacke, and slate, which are tilted into vertical attitudes, as well as on the intrusives. The unconformity is thus clearly proved. The Cobalt conglomerate on Pearl Point (Fig. 2) contains numerous fragments of the greywackes, slates, and porphyries of the Timiskaming series. The Timiskaming therefore suffered intense folding, intrusion, and peneplanation before the Cobalt was laid down on it.

The thickness of strata eroded during the peneplanation which took place before the Cobalt series was deposited has never been estimated, but some data obtained in Boston Township permit of the calculation of a minimum figure. Careful observations made on the structure of the Keewatin in this district and elsewhere throughout northern Ontario and Quebec, show, wherever studied, that it has been thrown into close isoclinal folds, usually upright or slightly inclined, but occasionally overturned. Such a fold is illustrated in Figure 4. Erosion has cut so deeply into these folds as to remove the crests entirely, so that only the steeply inclined limbs may now be observed. In three or four places the writer has found good outcrops directly across the axis of such a fold, and was thus able to observe directly that the width of the flattened strata along the axis was slight, perhaps 100 feet or thereabouts. It is clear therefore that the minimum amount of erosion necessary to produce such a condition, represented by *CC′* in Figure 4, can be determined by measuring the thickness of the strata by the usual methods. All that is necessary for such a determination is a knowledge of the position of the axis of an anticline and the next adjacent syncline, which may be observed directly or calculated from the position of some recognizable horizon.

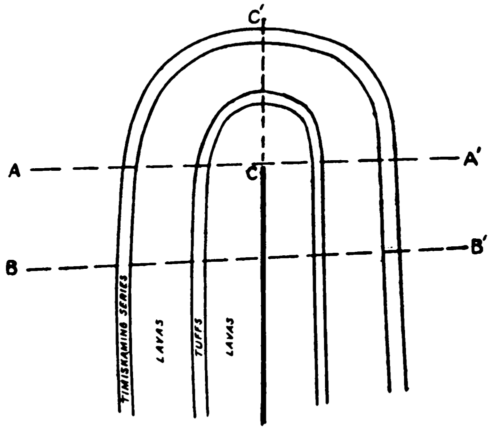

FIG. 4.—Diagram illustrating method of calculating minimum amount of erosion at the base of the Cobalt series.

It need scarcely be emphasized that such a determination of the amount of erosion is no more than a minimum, placing the erosion surface in the position *AA′* (Fig. 4). It gives no hint of the additional thicknesses of rock removed in the formation of any lower erosion surface *BB′*.

In Boston and Otto townships a recognizable horizon for purposes of measurement is afforded by a band of well-stratified tuffs approximately 1,300 feet in width which are here interbanded with the basalt flows (Fig. 5) This band was determined, by methods described,[1] to have the north side as the upper. In the south part of Boston Township there is a similar band, the upper side of which was determined by similar means to be the south. The bands are of about the same width, the southern one somewhat the wider, as it contains a larger proportion of interstratified basalt flows which could not be separated in mapping. There can be no doubt therefore that the two bands form the limbs of an anticline whose crest has been cut off by erosion. The dips of the strata in both bands average about 70 degrees or higher. At their nearest point of approach the bands are about 17,000 feet apart, so that the axis of the anticline may be considered to be approximately 8,500 feet from the base of each band.

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[1] *Jour. Geol*, Vol. XXVII (1919), p. 75.

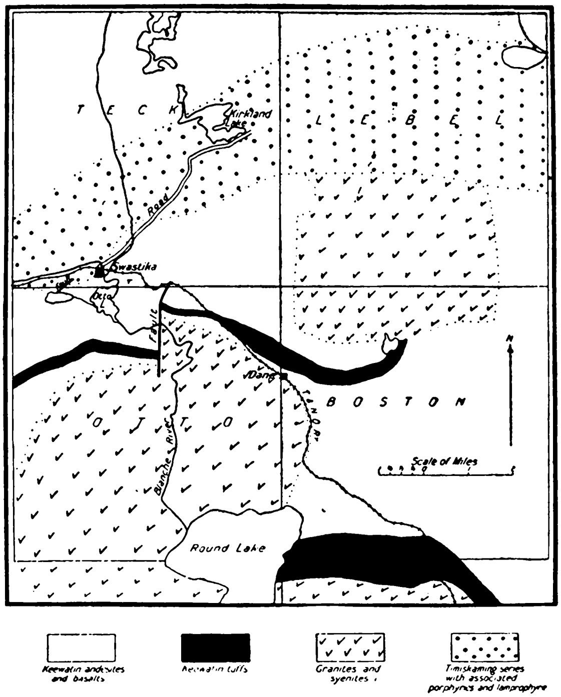

FIG. 5.—Sketch map showing the tuff bands in Boston and Otto townships and their relations to the Timiskaming series.

The syenite batholith to the north of the tuffs in Boston Township prevents the calculation there of the thickness of the Keewatin between the tuffs and the Timiskaming series. About 5 miles to the west, however, in Otto Township, where the tuffs approach the Timiskaming most closely, there is a width of 8,250 feet between the base of the Timiskaming and the base of the band of tuffs. The sum of these two numbers, 8,500 and 8,250, therefore represents the minimum width of the Keewatin between the center of the anticlinal fold and the base of the Timiskaming. Assuming an average dip for the Keewatin of 60 degrees, which is smaller than the average measurement, we arrive at a minimum thickness for the Keewatin of approximately 15,000 feet.

Overlying the Keewatin there was at least 3,600 feet of Timiskaming series so that there were at least 18,600 feet of strata in all removed by erosion before the deposition of the Cobalt series. The actual amount may have been much more than this, however.

AGE

The descriptions of preceding sections show definitely that the Timiskaming series is post-Keewatin and pre-granitic in age, and antedates the Cobalt series by a period sufficient for the peneplanation of a mountainous area, with removal of at least 18,600 feet of rock. Its age may, however, be more closely delimited by the following consideration.

The Cobalt series outcrops in an almost continuous sheet from Larder Lake southwest to the north shore of Lake Huron. Throughout this whole section it lies in gentle open folds, with dips rarely exceeding 20 degrees, and rests on a correspondingly gently warped peneplain that bevels closely folded rocks cut by granitic intrusives. Near Lake Huron, however, this peneplain is directly overlain by the Bruce series, and the Cobalt series overlies the Bruce. There is an erosional unconformity between the Cobalt and Bruce series, representing a time interval sufficient for the removal of 1,700 feet of sediments,[1] but little or no structural unconformity; so that both series, where not disturbed by the Keewanawan folding and intrusion, lie in the same open gentle folds as the Cobalt to the north. It seems evident therefore that the Timiskaming, which forms part of the ancient, tightly folded, peneplaned basement must be pre-Bruce as well as pre-Cobalt.

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[1] W. H. Collins, *Geol. Surv. Can.*, *Museum Bulletin No. 8*, 1914.

W. H. Collins has recently shown that the stratigraphy of the Bruce series in Ontario is closely similar to that of the Lower Huronian of the Marquette region.[1] As the gap between the two districts is filled with Palaeozoic sediments this evidence is probably the best we shall ever obtain for the correlation of the Huronian of northern Ontario with that of the south shore of Lake Superior. Accepting it therefore, it follows that the Timiskaming series is pre-Huronian.

DESCRIPTION OF THE TIMISKAMING SERIES

In Teck Township the Timiskaming forms a syncline whose width averages pretty closely 1½ miles, after subtraction of the widths of intrusive masses of porphyry and lamprophyre. The dip of the limbs varies from 60 degrees to 90 degrees. The maximum thickness, calculating the dip of both limbs at 90, is 4,000 feet; the minimum, calculating both limbs at 60, is 3,400 feet. Commonly the south limb dips 80 to 90 degrees, the north limb about 60 degrees. Calculated on this basis the thickness amounts to about 3,600 feet, a figure which probably approximates the truth. In the western part of McVittie Township, 15 miles east, where the whole width of the syncline is also exposed, the calculated thickness is closely the same.

In Teck Township the whole thickness is made up of interbanded conglomerates and greywackes. At the western end of the syncline near Kenogami station there is a basal band of conglomerate 400 feet thick, overlain by a massive greywacke containing an occasional pebble, the thickness of which is at least 125 feet, and may be much greater. About 3 miles to the east of this near Swastika, the basal conglomerate is over 1,000 feet thick. While there was not time available to make detailed sections of the Timiskaming of Teck Township, these observations, coupled with the alternating conglomerate-greywacke composition throughout the entire thickness, indicate pretty clearly that the sediments here are of subaerial origin, such as beach deposits, or continental

[1] W. H. Collins, memoir in preparation.

deposits from torrential streams; and that the beds, if worked out in detail, will be found to be lenticular in shape.

The basal conglomerate near Kenogami station is composed almost entirely of detritus from the underlying volcanic series. In a railway cut here it is in contact with a serpentinized agglomerate or flow breccia of very unusual composition and appearance. The conglomerate contains numerous rounded pebbles of this material, so that the fact of unconformity is indubitable. These pebbles are also slightly schistose, although the conglomerate and all the other pebbles are quite massive, so far as observed; so that some deformation must have preceded the deposition of the conglomerate.

The conglomerate is crowded with pebbles, particularly near the base where 75 to 80 per cent of the total mass is pebbles. They vary in size up to a foot in diameter, but the majority are from 1 to 4 inches in diameter. They are mostly pretty well rounded and worn. About half of them are longer in one direction than the other, presumably due to their original structure, and the long axes commonly lie parallel to the plane of bedding in the conglomerate. All the pebbles appear to be massive, with the one exception noted above. Approximately 50 per cent are of the light-colored cherty tuff which commonly accompanies rhyolite flows; some of these are probably also rhyolite. Thirty-five to 40 per cent are basalts and gabbros, the latter probably from the coarser-grained parts of basalt flows. The remaining 10 to 15 per cent consist of red jasper, banded chert, porphyry, and the peculiar breccia mentioned above, with here and there one of reddish granite and syenite. In the upper parts of this bed there is a somewhat greater variety among the pebbles. Quite a number are to be found of a quartz porphyry common among Keewatin rocks, and grayish granite pebbles are fairly common.

The matrix of the conglomerate is a rather coarse grit, composed of the small fragments of the rocks which supplied the pebbles.

The conglomerate is massive and unsheared. The stresses developed during the folding have been relieved, not by schisting, but by jointing accompanied by a number of small faults.

Many of the conglomerate beds lying at some distance above the base of the series, as in the second locality mentioned above about 3 miles to the east of Kenogami, are markedly different from the basal beds, in that the pebbles are mostly small and very sharp angled, so that the rock at first glance gives the impression of a breccia instead of a conglomerate. Cross-bedding is frequently found here, and in general the beds are only a few inches or feet in thickness instead of being thick and massive.

The writer has been unable to make any personal examination of the Timiskaming in Lebel and Gauthier townships, but 12 miles to the east, in the western end of McVittie Township, the stratigraphy of the series is notably different from that described. The series in this third locality is well exposed on the north side of the syncline, on Binney Lake and eastward. On Binney Lake there is approximately 600 feet of interbedded conglomerate and greywacke at the base, striking north 80 degrees east and dipping 60 degrees south. The composition of the conglomerate is approximately the same as at Kenogami, but instead of being in thick massive bands it forms bands a few inches or feet in thickness, interstratified with greywacke. Only one heavy band of conglomerate was observed; it may be about 100 feet thick, and lies near the top of the conglomerate-greywacke complex. The remainder of the section is all massive, thick-bedded greywackes, except at the center of the syncline on Marjorie Lake, where there are some very impure quartzites, now partially altered to sericitic schists. The thickness of the latter was not measured, but is not over 500 feet at most. The total thickness along this section is about the same as in Teck Township, 3,600 feet.

The series maintains the same composition for about 2 miles to the east of the Binney Lake section, except that in this distance the central schistose quartzites become much purer and whiter. About 2 miles to the east of Binney Lake, however, and eastward past Malone Lake as far as Bear Lake the amount of basal conglomerate becomes much larger. The thickness of the basal part is perhaps not any greater than at Binney Lake, averaging about 600 feet; but instead of containing a great deal of greywacke, the whole thickness is of massive conglomerate, while occasional beds of conglomerate were also found in the greywacke for more than a quarter of a mile south of the main conglomerate band. Little can be said of the remainder of this section, since the rocks above the conglomerate are broken and replaced by a large mass of intrusive porphyry. To the south of the porphyry on Bear Lake, however, a new formation appears, a thin-bedded argillite of about the same composition as the greywacke.

The basal conglomerate was next observed on the west end of Barber Lake, about a mile to the east of Bear Lake. In this distance it has thinned remarkably to only 60 feet. It is overlain by about 100 feet of rather impure sandstone, to the south of which lie the greywacke and argillites of the series. The thickness of the latter was not directly determined and cannot be estimated, since the southern edge of the syncline is covered by Larder Lake. The conglomerate band outcrops along the south shore of Barber Lake, continuing to thin, until about a quarter of a mile east of the east end it was observed to consist of about a foot of rather coarse grit. It was not found again on the south side of the anticlinal nose here (Fig. 2), so that the base of the series for at least half of a mile appears to be a rather impure sandstone. As this is very badly sheared, however, for a width of perhaps 25 feet from the contact, and converted into a featureless sericite schist, it is possible that pebbles may have existed in it but were obliterated.

On the north side of the anticlinal nose, the conglomerate reappears again, gradually thickening to about 30 feet. It consists, like that around Binney Lake, of thin pebbly beds interstratified with beds of greywacke. It maintains this character east of Beaver Lake, where the syncline (Fig. 2) pinches out. On the north side of this syncline, for a distance of about 2 miles east of Beaver Lake, the conglomerate is hidden by drift, and where it reappears it is a rather thin band, perhaps 30 or 40 feet in thickness, over which lies about 700 feet of rather impure quartzite. This is overlain in turn by a second band of conglomerate about 300 feet thick. To the south of this band of conglomerate the rocks are grits and impure quartzites, very poorly exposed. To the east, the lower conglomerate disappears entirely within a mile, replaced by beds of impure quartzite intruded by masses of porphyry. The total width of this mixture is 1,400 feet, of which about three-fourths is porphyry. To the south of this lies nearly 1,000 feet of interbedded argillite and impure sandstone, over which again lies some 250 feet of conglomerate with some interbedded impure quartzite.

The writer's attention has been called by Mr. M. E. Wilson to a peculiarity of some of the sheared conglomerates of the Larder Lake district, which here and there are found to contain squeezed, pebble-like masses distinguished by the presence of chrome-mica or fuchsite. Fuchsite is also characteristic of the altered and sheared porphyry masses of the region, and Wilson is inclined to believe that unconformity is thus indicated between the porphyry and the conglomerates. This, however, is obviously impossible, since, as already shown (p. 317), the porphyries cut the conglomerate and the other members of the sedimentary series. The writer made a careful examination of the composition of the conglomerate wherever it was found unsheared or only slightly sheared, but found no pebbles containing fuchsite. It seems indubitable therefore that the fuchsite in the pebbles of the sheared conglomerate must be formed during the shearing of the conglomerate after its deposition. Fuchsite is not alone characteristic of the sheared carbonated porphyry of the Larder Lake district, but it has been found by the writer in several places in Keewatin rhyolites and rhyolite tuffs which have been subjected to carbonate alteration and subsequent shearing. Pebbles of the Larder Lake porphyry are not found in the Timiskaming conglomerate here, but pebbles of rhyolites in all stages of alteration are common. It is likely therefore that some of these have given rise to the fuchsite pebbles in the mashed types of conglomerate.

The sediments were not traced farther to the east, as the next 2 miles is heavily drift-covered, and beyond this again the Cobalt series overlies. To the east in Quebec the rocks are described by J. A. Bancroft as follows:

> Exposures of a much metamorphosed conglomerate, arkose and greywacke appear at intervals on both sides of the (Kinojevis) river for about three-fourths of a mile. Either vertical or dipping very steeply to the north, and striking nearly east and west, these rocks may be traced to Keekeek lake and the upper portion of the river bearing the same name (about 16 miles). . . . . The conglomerate is chiefly composed of pebbles of Keewatin greenstone, although pebbles of granite and diorite are of frequent occurrence. Originally the

> pebbles were well rounded and varied in size up to a foot across; they have been so flattened by pressure that today they possess lenticular forms. . . . . The matrix of the conglomerate as well as the arkose and greywacke have been quite universally converted into biotite schists, partially or completely recrystallized, yet repeatedly exhibiting their originally clastic character. . . . . That the sediments rest unconformably upon the Keewatin is evidenced by the pebbles in the conglomerate and the position which some of the exposures bear to those of the Keewatin.

M. E. Wilson described the sediments thus:

> The Pontiac series in the district north of Kekoko and Kinojevis lakes is composed of greywacke, arkose, and conglomerate, which extends in an east-west belt having a width of about 2 miles. . . . . These rocks are all greenish gray or gray in colour, and have all been more or less mashed. The greywacke is everywhere recognized by the quartz grains which it contains. . . . . The arkose is of local extent and differs only from the greywacke in containing more fragments of acidic minerals. The conglomerate consist of mashed pebbles and boulders of granite, rhyolite, and quartz porphyry in greywacke matrix. No pebbles or boulders of basic rocks were seen.

Wilson also indicates on his map that the dips vary from 50 degrees north to vertical.

NEMENJISH SERIES (?)

In the writer's last paper on this subject[1] there were indicated some reasons for believing that a part of the body of sediments mapped as Pontiac series might in reality belong to an older sedimentary series which there were some reasons for believing to be of Grenville age. Briefly stated, these reasons were the absence of basal conglomerate at the east end of the sedimentary band and elsewhere, the occurrence of amphibolites in the Pontiac series, while amphibolites are not elsewhere found in the Mattagami (or Timiskaming) series, but are common in the Grenville and its supposed equivalents; and the occurrence of undoubted Grenville within 30 miles to the south and to the east. The facts described in this paper yield additional evidence on this point. The Timiskaming of Ontario is pretty uniformly about 3,600 feet in thickness through a band over 30 miles in length. As Figure 3 shows, in Quebec, 15 miles to the east, the band widens sharply to more than 10 miles, throughout which the dips average 45 degrees north except within 2 miles of the northern edge where they are steeply north or vertical. The dips of the northern edge are due to overturned folding, as the writer has shown.[1] If the series as mapped is all one, its thickness in Quebec is at least 22,000 feet, unless the outcrops have been repeated by folding; but Wilson records no southward dips. On the contrary, the width of the conglomerate-greywacke band, the descriptions of which correspond so closely with those of the Timiskaming of Ontario, is uniformly about 2 miles, or very little greater than that of the Timiskaming to the west. While it is possible therefore that the series does increase in thickness from 2,600 to 22,000 feet by depositional processes within less than 15 miles, the writer considers it more likely, in view of the other evidence, that only the band of conglomerate and greywacke along the north edge of the series as mapped is of Timiskaming age, while much or all of the biotite schists and amphibolite to the south of this band belongs to the older sedimentary series.

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[1] *Jour. Geol.*, Vol. XXVII (1919), p. 201.

ORIGIN OF TIMISKAMING SERIES

The well-stratified nature of the Timiskaming sediments, especially of the upper members of the series, such as the argillites of Larder Lake, indicates that they have been laid down in a body of standing water. The well-rounded pebbles in the basal conglomerate indicate fairly long-continued wear, while the angularity of the fragmental material, in the beds above the proximate base, and its unsorted character indicate either that it has not been carried far before deposition, or else that if carried far the transportation has been very rapid, such as would be afforded by torrential streams from a mountainous area. The undecomposed character of the particles composing the greywackes, etc., indicate rapid removal of detritus after disintegration, such as occurs in any district where there is no vegetation to hold the rock particles in place long enough for decomposition to take place. The great thickness of the basal conglomerate in places and its rapid variations in thickness are characteristic of continental or subaerial deposits as also is the cross-bedding frequently to be observed in the conglomerates and interbedded greywackes. The change in the character of the sediments, from a series of interbedded conglomerate and greywacke on the west to a series on the east in which conglomerate is a relatively minor part, might indicate that the territory to the west which supplied the sediments was higher and more rugged, with more rapid streams, than that which supplied the sediments to the east. This conclusion is strengthened by the fact that the material composing the upper conglomerates in Teck Township is noticeably more angular than that to the east, so much so in fact that many of the conglomerates resemble breccias.

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[1] *Ibid.*, p. 200.

We may infer therefore a large lake or, on account of the thickness of the series, more probably a transgression of the sea due to gradual submergence. To the west of what is now Teck Township there must have been a fairly rugged mountainous or semi-mountainous area, flattening to the east. Vegetation was entirely lacking or almost so. As the sea advanced, a normal thin basal conglomerate was first formed, composed of fairly well-rounded fragments of the underlying rocks. This was supplemented by sharp-angled material brought down by streams, in large amount in the west, in lesser amount in the east. As submergence continued, the deposition of conglomerate ceased altogether in the east to be replaced by that of greywackes and finally argillites, with small amounts of arenaceous materials locally. Submergence apparently was never great enough to cover the mountainous area to the west; or, if so, with it disappeared the last source of sedimentary material in important amount; since the conglomerates and greywackes of Teck are not overlain by finer-grained beds.

NOMENCLATURE

A brief discussion of the nomenclature of the granite of Timiskaming district may be added here, as closely related to the main purpose of this paper. The term Algoman has recently been applied by Miller, Burrows, and others, when referring to granites intrusive into the Timiskaming series but underlying the Cobalt series.[1] The term Algoman was first used in the Rainy Lake district by A. C. Lawson, and was defined by him as applying to granites intrusive into the Middle Huronian but underlying the Upper Huronian or Animikie.[1] The transfer of this term to Timiskaming district 500 miles to the east was made upon a correlation of the Cobalt series with the Animikie, since both series are flat lying and overlie a great unconformity, and a secondary decision that the Timiskaming, as a folded sedimentary series lying beneath the Animikean, was probably Lower Huronian. But with the determination of the Timiskaming series as pre-Huronian in age, while the intrusive granites are found in the Lake Huron area to underlie the Bruce or Lower Huronian, it is clear that the use of the term Algoman is entirely unjustified.

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[1] *Ont. Bur. Mines, Rept. No. 22*, Part 2, pp. 123–27, 1913.

In its place the writer would apply the term Laurentian to these granites. This much-abused term has had an eventful history. It was first applied by Sterry Hunt in 1852 to what had up to then been known as the Metamorphic series, or lower pre-Cambrian. At that time these rocks were supposed to be all sedimentary, on the grounds that their gneissic textures were the remains of original bedding. They had been described in 1847 as consisting of a lower group of reddish and grayish syenitic gneisses, much contorted and generally at high angles, succeeded by an upper series containing important beds of crystalline limestone interstratified with the syenitic gneiss. The two groups were considered to be conformable. Between 1862 and 1865 the Laurentian, still supposed to be all sedimentary, was further subdivided into the Upper Laurentian, Labradorian, or Norian, in which subdivision were placed the great anorthosite bodies in the vicinity of Montreal, and the Lower Laurentian, which was further subdivided into the basal Ottawa Gneiss and the overlying Grenville series of interbedded crystalline limestones, quartzites, and gneisses. One of the first suggestions that part of these rocks might not be sedimentary but intrusive seems to have come from A. R. C. Selwyn, in the *Summary Report of the Geological Survey Canada* for 1877–78, but the first definite conclusion in this regard drawn from field observation is by Vennor, who reported in the director's *Summary Report of the Geological Survey of Canada* for 1879–80 that some of the anorthosites north of the St. Lawrence appeared to be intrusive in the crystalline limestones. Vennor, however, resigned from the Geological Survey in the next year and his report was never published. In 1885, A. C. Lawson published the results of his work in the Rainy Lake region, and demonstrated conclusively that the gneisses there, previously known as Laurentian, were not sedimentary rocks at all, but intrusive; and that, whatever the origin of the gneissic textures, they could not possibly be accounted for as relics of original bedding, since the rock had clearly been fluid enough at one time to permit of the movement through it of fragments of Keewatin. In 1887 he expressed the view that the foliation was due to flowage movements prior to complete solidification. He also considered that the granite gneisses represented the fused floor on which the Keewatin and Couchiching rocks had been laid down, and definitely reparated the term Laurentian to apply only to the intrusive gneisses. In the same year F. D. Adams anounced in the *Summary Report* that his study of the anorthosites north of the St. Lawrence River had shown that the gneissic and massive portions were gradational into each other, so that there was little doubt but that the whole body was of igneous origin. A second statement to the same effect was made by him in the *Summary Report of the Geological Survey* for 1891; but his full report on the subject was not published till 1894. A second report published in 1895 discusses the question of the Lower Laurentian in the district north of Montreal, previously subdivided into the Ottawa gneiss and the Grenville series; and shows that gneissic structures may have originated in many ways other than by original bedding, and that much of the gneiss here, particularly the Ottawa gneiss, is of igneous origin, although gneisses are present also whose composition indicates that they are altered sediments.

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[1] *Geol. Surv. Can. Mem. No. 40*, p. 82. 1913.

From this time it was generally recognized that the granite gneisses are of igneous origin, not sedimentary, and as the sedimentary parts of the old Laurentian series were already known in the literature as the Grenville series, the name Laurentian was restricted to its granitic parts. In many places, particularly in Canada, the name was indiscriminately applied to any pre-Cambrian granite of unknown age; but south of Lake Superior, where careful detailed geologic work was being done following the discovery of the great copper and iron deposits, it was applied more rigidly only to granites unconformably below the Lower Huronian. In 1905, the International Committee on pre-Cambrian nomenclature defined the term Laurentian as applicable to "the granites and gneissoid granites which antedate or protrude through the Keewatin, and which are pre-Huronian." They added, "In certain cases this term may also be employed, preferably with an explanatory phrase, for associated granite of large extent which cut the Huronian or whose relations to the Huronian cannot be determined."

From 1905 to the present time the term Laurentian has gradually fallen into disuse in Canada. Careful detailed geologic work has been carried on in this period by the Geological Survey, with the use of local names to designate formations, and without any attempt at general correlation until all the necessary evidence has been obtained. In general, no names whatever have been applied to the granite masses, although Miller has called the granite around Cobalt the Lorrain granite. But with the writer's work of last summer, which completed the mapping of a large nuclear area in Ontario and Quebec, and brought in the evidence necessary for correlation and age determination, it appears possible to apply the term Laurentian correctly and rigorously.

The writer suggests that the term Laurentian be defined, in the more rigorous sense intended by the International Committee, to apply only to those granites and granite gneisses which intrude all rocks below the peneplain at the base of the Lower Huronian. Older granites, which will undoubtedly be found some day since the Timiskaming series contains granite pebbles in places and granite pebbles are found in Keewatin tuff beds occasionally, must receive other names when found. Laurentian will therefore apply to all granitoid masses intrusive into the Timiskaming series, and cut off by the peneplain which bevels it. This use of the term for northern Ontario corresponds to the usage in the Marquette district, the nearest pre-Cambrian on the south shore of Lake Superior; where the Laurentian granite is that which underlies the Lower Huronian.

SUMMARY

The present paper is a continuation of that published last summer. Data obtained during the summer of 1919 have shown that the sedimentary rocks at Larder Lake, Ontario, are not interstratified with the Keewatin, as formerly supposed, but are parts of a synclinal sedimentary series overlying the Keewatin unconformably. The series forms a lineal continuation of the Timiskaming series of Kirkland Lake, to the east.

It is shown that the Timiskaming series of Kirkland and Larder Lakes is to be correlated with the Mattagami series of northern Quebec. The name Timiskaming series is applied to both.

The age of the Timiskaming series is discussed, and the conclusion drawn that it is pre-Huronian.

Descriptions as detailed as possible are given of the stratigraphy and thickness of the Timiskaming series, and the mode of origin of the series is discussed.

As the determination of the age of the Timiskaming is also indicative of the age of the granites which intrude them, a brief consideration is given to the question of the proper nomenclature to be applied to these granites. The conclusion is reached that they may properly be termed Laurentian.